DRAFT-TRANSLATION

DETERMINATION OF THE DEGREE OF SOLAR CORONA POLARIZATION BY THE OBSERVATIONS OF THE SOLAR ECLIPSE OF JUNE 30, 1954

(Opredeleniye stepeni polarizatsii solnechnoy korony po nablyudeniyam solnechnogo zatmeniya 30. VI. 1954 g.)

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ABSTRACT

On the basis of photometry of solar corona photographs obtained on 30 June 1954 by means of a three-lens camera with polaroids, determined are the degree of polarization p of the corona, and the polarization angle α for eight radial directions at distances of 1.5 — 5.0 solar radii $R_\odot$ from the center of the solar disk. In the case of western equatorial directions it was effected to distances up to 7 $R_\odot$.

COVER-TO-COVER TRANSLATION

The study of polarization of the continuous coronal radiation constitutes a great interest for ascertaining the structure and the shape of the corona, for the determination of electron concentration and for a series of other solar physics' problems. A series of works have been devoted to that subject matter [1 — 4]. But very few works were specifically devoted to corona measurement at great distances (i.e. > 4 $R_\odot$ from the center of the solar disk).

An attempt is made in the present work to determine the polarization of the corona at distances from 1 to 7 R. from the center of the solar disk. To that effect were utilized materials obtained by the author during the total solar eclipse of 30 June 1954 at a place named Kozelets, 75 km to the north of Kiev.

Photographing of the corona was effected by a three-lens camera with Apo-Tessar objectives 1/9, f = 45 cm, providing three simultaneous photographs of the corona at three polaroid positions whose polarization planes were oriented at 120° angle with one another. The polarization plane of the first polaroid coincided with the projection of the axis of the Sun. The objectives were provided with a yellow filter. The photographs were obtained on the rot rapid Agfa plates with an 87 s.exposure. The calibration was conducted with the help of a spectrograph with a stepwise clearing agent. The calibration plate and the plate with the photograph of darkening were taken from the same box. The characteristic curve was constructed for the region of wavelengths corresponding to the system filter+plate. The photometric evaluation was effected on a improved microphotometer МФ-4 with an adapter from a photomultiplier and electron potentiometer ЭПП-09. The microphotometer's slot cut out a 0.05 x 0.05 mm^2 surface on the plate (0.025 $R_\odot$); 1 mm on the photoplate corresponded to 19.5 mmm on the register.

The photometric evaluation was conducted along N - S and W - E directions and at an angle of 45° between them. Every photometric cut was effected twice (in a direct and reverse directions), and four pairs of curves of the form indicated in Figure 1 have been obtained. The stability of the device's operation was checked by background recording in the determined part of the negative prior and after the recording of each direction. The photometric processing of the material was conducted by the generally-accepted method. The determination of the degree of polarization and of the position of its plane was made by the graphic method due to D. A. Rozhkovskiy [6], and which is based on V. G. Fesenkov formulas [7]. Such determinations in the 1.5 — 3.0 $R_\odot$ interval from the center of the disk were made every 0.25 $R_\odot$, and at great distances — at every 0.5 $R_\odot$.

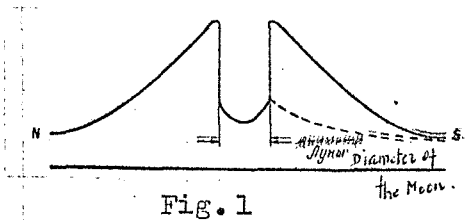

Fig. 1

The accounting of the background of non-coronal origin (light diffusion in the apparatus, and diffusion of the sky light) was carried out by a method proposed in reference [8], i.e. a curve representing the aggregate of diffused light was plotted on every registrogram (see fig. 1 — dotted line), which was an interpolation between the density of darkening on the Moon's disk, and that at distances of the order of $7\,R_\odot$, where the intensity of the corona already was neglectingly small in comparison with the background.

The results of measurements of the degree of polarization p (in percent) for the selected directions are compiled in Table 1. Figures 2 and 3 give the graphs of p as a function of the distance $R/R_\odot$ from the center of the solar disk. Theoretical curves of polar and equatorial polarization of the directions for the corona of the minimum epoch are also plotted in Figure 2. As may be seen from the graph, observed and theoretical polarization curves for the polar direction are close. It is likely that the polarization in the equatorial direction, for the curves of which there is divergence, depends to a greater degree on the shape of the corona. It had in the western direction two rays elongated along the equator, and it was more intense. This gave the possibility of determining the polarization till $7\ R_\odot$ from the center of the disk.

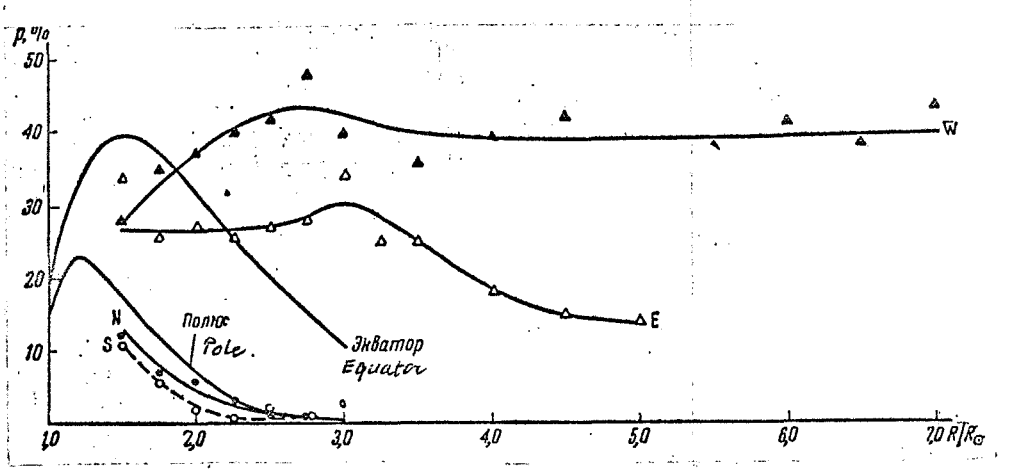

Fig. 2

In Fig. 2 there is a maximum for the westerly direction, which is located farther than the theoretical. M. A. Vashakidze [4] assumes that the polarization maximum for a more intense corona shifts farther away from the Sun's limb.

TABLE 1.

$R/R_\odot$	N	S	E	W	NE	SW	SE	NW
1,50	12	11	34	28	18	31	20	21
1,75	7	6	26	35	9	24	9	18
2,00	6	2	27	37	9	27	10	13
2,25	3	1	26	40	10	31	14	11
2,50	1	2	27	42	10	34	12	8
2,75	1	1	28	48	12	34	14	8
3,00		3	34	40	11	35	13	10
3,50			25	36	15	38	17	7
4,00			18	39	12	38	12	9
4,50			15	42	10	37	10	12
5,00			14	36				9
5,50				38				
6,00				41				
6,50				38				
7,00				43				

Data on the polarization angle α (in degrees) are presented in Table 2 and Figure 4. Angles between the polarization plane at a given point and the radial direction are given in Table 2. The positive angle is counted clockwise from the radius. The estimate of errors p and is difficult, for these magnitudes depend on three values of intensity everyone of which liable to include an error of any sign. In order to evaluate the errors of the obtained polarization values, determined were the relative errore $\Delta p/p$ for the various distances in several directions from the center of the disk. The $\Delta p/p$ computation have been

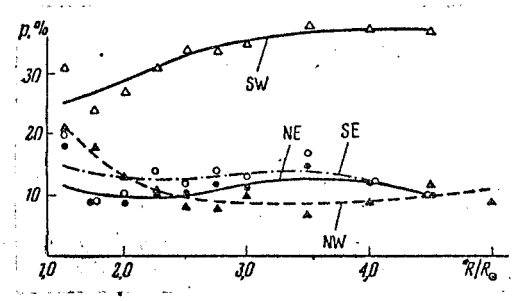

Fig. 3

conducted for various (sign-wise) variants of error values of the three intensities entering into the expressions for the determination of $\Delta p/p$. It was established in working out this process, that the case when the three intensities have the same sign is little probable. A maximum value for $\Delta p/p$ was chosen among several variants of $\Delta p/p$ calculation. It resulted that for distances of 3.0 and 4.0 $R_\odot$ from the center of the disk, $\Delta p/p$ was respectively equal to 15 and 65 percent. For a 5 $R_\odot$ the errors exceed 100 percent. It is necessary to note that measurements at a distance of 1.5 $R_\odot$ are subject to substantial errors on account of greater density of the negative. Different errors are obtained for various directions. For technocal reasons, the relative error $\Delta p/p$ in the NW direction is of 25% at a distance of 2.5 $R_\odot$, and $\sim 90\%$ — for 3 $R_\odot$. Apparently, the polarization values are in this case underrated. In the SW direction $\Delta p/p$ are respectively equal to 30 and 85 percent for 3 $R_\odot$ and 4 $R_\odot$. The fundamental error for p is probably linked with the errors in the accounting of diffused light.

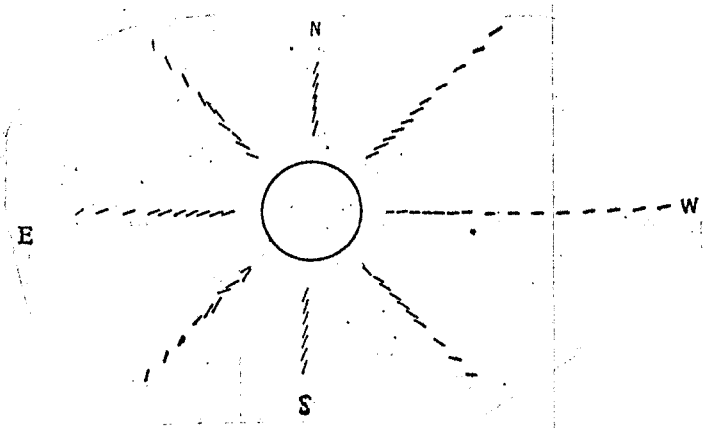

Fig. 4

The absolute error was determined for the polarization angle . Its expression was obtained by way of Fesenkov formula differentiation The computation of errors for various directions has shown that the westerly direction bears the smallest errors (at 3 $R_\odot$ from the center the error is $\pm 2^\circ$ and at 4 $R_\odot$ it reaches $\pm 9^\circ$). It may be seen from Table 2, that the polarization in that direction may be considered as

radial. In the case of the easterly equatorial direction, the polarization plane is as an average deflected from the radial direction by 18°.

The same photographs were used in the work of reference [9] for the determination of the polarization in equatorial rays by another method. The polarization course obtained by us, and the polarization plane position for equatorial directions coincide with the results of reference [9]. However the polarization obtained in the latter is higher, and that is explained by the fact that the problem there was to obtain polarization in rays. In connection with this, maximum values of intensities at every transverse cross section of the ray were selected during the processing. The polarization may also be considered as radial in the remaining directions within the limits of the precision of measurements. The NW direction resulted the worst, just as at the computation of errors for p. The same may be seen from the same values α (Table 2). Generally-speaking, the determination of the angles α is beset with greater errors than that of the degree of polarization p. The sources of these errors may be the result of inaccurate accounting of the diffused light, of an imprecise polaroid orientation, and also of an insufficiently precise determination of position abgles of photometric cuts, as a result of the smallness of the corona image.

TABLE 2

R/R⊙	N	S	E	W	NE	SW	SE	NW
1,50	+ 8	+10	—16	— 2	—21	+ 1	+ 8	+17
1,75	+ 4	+10	—19	— 4	—14	—14	— 6	+19
2,00	+ 3	+14	—18	— 4	— 3	—15	+ 5	+29
2,25	+ 6	+15	—17	— 1	— 5	—13	+35	+31
2,50	+16	+18	—20	0	+ 8	—13	—11	+31
2,75	+16	+24	—17	0	+ 3	—13	— 1	+10
3,00		+12	—16	— 4	+11	—13	0	+ 9
3,50			—15	0	+15	—13	—16	+19
4,00			—20	0	+15	—25	—40	+10
4,50			—30	0	+31	—35	—27	+18
5,00			—24	— 2				+ 9
5,50				— 5				
6,00				—10				
6,50				—13				
7,00				—10				

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